PATENT ABSTRACTS OF JAPAN

(11)Publication number : 11-317452
(43)Date of publication of application : 16.11.1999

(51)Int.Cl. H01L 21/768
H01L 21/28

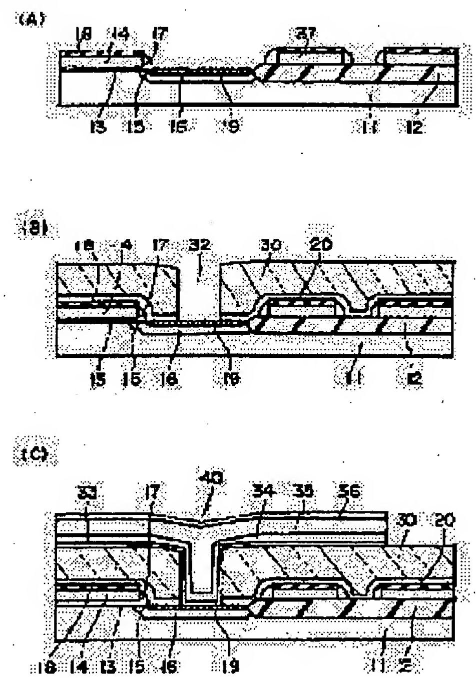
(21)Application number : 10-204396
(22)Date of filing : 03.07.1998

(71)Applicant : SEIKO EPSON CORP
(72)Inventor : ASAHINA MICHIO
MORIYA NAOHIRO
MATSUMOTO KAZUMI
TAKEUCHI JUNICHI

(30)Priority

Priority number	Priority date	Priority country
09249535	29.08.1997	JP
10 67867	03.03.1998	JP

(54) SEMICONDUCTOR DEVICE AND MANUFACTURE THEREOF



(57)Abstract:
PROBLEM TO BE SOLVED: To provide a semiconductor device without voids and breaking of wires and having superior step coverage using Al or an Al alloy for the conductive material in a connection hole, and to provide a manufacturing method of the semiconductor device.
SOLUTION: A connection hole 32 is formed on the interlayer insulating film, consisting of a SiO_2 film 20 and a BPSG film 30 formed on a semiconductor substrate 11 containing elements. After the gasified component contained in the interlyaer insulating film has been removed by heat treatment at 300 to 550° C under a decompression state, a barrier layer 33 consisting of a TiN film and a Ti film is formed on the surface of the interlayer insulating film and the connection hole 32. The substrate is cooled down to 100° C or lower, and the first Al film 34 consisting of Al or an Al alloy is formed on the barrier layer at a temperature of 200° C or lower. After a second Al film 35 has been formed thereon at 300° C or higher, a deposition layer consisting of a TiN antireflection film 36 is formed through a sputtering method. Then, the barrier layer, the first and the second Al films and the reflection preventing film are etched using mixed gas of Cl_2 and BCl_2. As a result, a metal wiring layer 40 is patternized, and Al is filled in the connection hole with satisfactory step coverage.

LEGAL STATUS
[Date of request for examination] 27.03.2003

[Date of sending the examiner's decision of rejection]
[Kind of final disposal of application other than the xaminer's decision of rejection or application converted registration]
[Date of final disposal for application]
[Patent number]
[Date of registration]
[Number of appeal against examiner's decision of rejection]
[Date of requesting appeal against examiner's decision of rejection]
[Date of extinction of right]

* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer.So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] The semiconductor device containing the aluminum film which consists of an alloy which makes a principal component the aluminum or the aluminum formed on the barrier layer formed in the front face of the contact hole which was formed on the semiconductor substrate containing an element, and the aforementioned semiconductor substrate, and was formed in the layer-insulation film from which the gasification component was removed by heat treatment, and the aforementioned layer-insulation film, the aforementioned layer-insulation film, and the aforementioned contact hole, and the aforementioned barrier layer.
[Claim 2] The semiconductor device which does not have a wetting layer for raising the wettability to this aluminum film between the aforementioned barrier layer and the aforementioned aluminum film in a claim 1.
[Claim 3] It is the semiconductor device which contains partially the oxide of the metal with which the aforementioned barrier layer constitutes this barrier layer in claims 1 or 2.
[Claim 4] The manufacture method of the semiconductor device containing the following processes (a) or (f).
(a) In the bottom of the process which forms a contact hole in the layer insulation film formed on the semiconductor substrate containing an element, and (b) reduced pressure The degasifying process which removes the gasification component contained in the aforementioned layer insulation film by heat-treating at the substrate temperature of 300-550 degrees C, (c) On the process which forms a barrier layer in the front face of the aforementioned layer insulation film and the aforementioned contact hole, the process which cools (d) substrate temperature at 100 degrees C or less, and the (e) aforementioned barrier layer, at the temperature of 200 degrees C or less On the process which forms the 1st aluminum film which consists of an alloy which makes aluminum or aluminum a principal component, and the aluminum film of the (f) above 1st, at the temperature of 300 degrees C or more The process which forms the 2nd aluminum film which consists of an alloy which makes aluminum or aluminum a principal component.
[Claim 5] The manufacture method of the semiconductor device which forms the 1st aluminum film directly on the aforementioned barrier layer, without forming the wetting layer for raising the wettability to the aluminum film of the above 1st on the aforementioned barrier layer in the aforementioned process (e) in a claim 4.
[Claim 6] It is the manufacture method of a semiconductor device that formation of the aforementioned process (e) and the aluminum film in (f) is performed by the spatter in claims 4 or 5.
[Claim 7] It is the manufacture method of a semiconductor device that formation of the aforementioned process (e) and the aluminum film in (f) is continuously performed within the same chamber in either of the claims 4-6.
[Claim 8] The aforementioned process (d), (e), and (f) are the manufacture method of the semiconductor devic continuously performed within the same equipment which has two or more chambers at which the reduced pressure state is maintained in ither of the claims 4-7.
[Claim 9] The manufacture method of the semiconductor device which includes the process which makes oxygen introduce into the aforementioned barrier layer after the aforementioned

process (c) in either of the claims 4–8.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] Especially this invention relates to the semiconductor device which detailed-izing is possible and has the contact structure using aluminum, and its manufacture method about a semiconductor device and its manufacture method.
[0002]
Background of the Invention] In semiconductor devices, such as LSI, the large contact hole of an aspect ratio is needed with detailed-izing of an element, densification, and multilayering. The embedding of the wiring material to such a contact hole is difficult, and has been an important technical technical problem in recent years. And to embed the inside of a contact hole by aluminum or an aluminium alloy useful as a wiring material is tried.
[0003] There is technology indicated by JP,64-76736,A as technology for that. In this technology, make aluminum or an aluminium alloy deposit in the temperature of 150 degrees C or less, subsequently aluminum or an aluminium alloy is made to deposit by the bias spatter first, and the manufacture method which embeds an aluminum film at two steps at a contact hole is indicated.
[0004] Although according to this technology the aluminum film of the 1st layer can be made to deposit comparatively uniformly and the remarkable improvement of the coverage nature is carried out, about the problem which the open-circuit section generates in the current carrying part in a contact hole by generating of a void etc., it cannot be said that it has fully been improved.
[0005]
[Problem(s) to be Solved by the Invention] Using aluminum or an aluminium alloy as conductive material in a contact hole, the purpose of this invention does not have generating of a void, an open circuit, etc., and is to offer the semiconductor device which has the contact structure excellent in step coverage, and its manufacture method.
[0006]
[Means for Solving the Problem] The manufacture method of the semiconductor device of this invention contains the following processes (a) or (f).
[0007] (a) In the bottom of the process which forms a contact hole in the layer insulation film formed on the semiconductor substrate containing an element, and (b) reduced pressure The degasifying process which removes the gasification component contained in the aforementioned layer insulation film by heat-treating at the substrate temperature of 300-550 degrees C, (c) On the process which forms a barrier layer in the front face of the aforementioned layer insulation film and the aforementioned contact hole, the process which cools (d) substrate temperature at 100 degrees C or less, and the (e) aforementioned barrier layer, at the temperature of 200 degrees C or less On the process which forms the 1st aluminum film which consists of an alloy which makes aluminum or aluminum a principal component, and the aluminum film of the (f) above 1st, at the temperature of 300 degrees C or more The process which forms the 2nd aluminum film which consists of an alloy which makes aluminum or aluminum a principal

component.
[0008] One of the features in the manufacture method of this semiconductor device is to include the process (degasifying process) which removes the gasification component contained in the aforementioned layer insulation film under specific conditions in a process (b). By passing through this degasifying proc ss, generating of gas, such as water contained in a layer insulation film, nitrogen, hydrogen, or oxygen, can be suppressed in a next process, for example, the formation process of the 2nd aluminum film performed under a high temperature service 300 degrees C or more etc.
[0009] According to the invention-in-this-application person, the gas which occurs from such a layer insulation film being absorbed by the barrier layer, and not being absorbed by the aluminum film in a contact hole is checked. Therefore, the wettability fall of a barrier layer and generating of a void by such gas existing between a barrier layer and the 1st aluminum film can be certainly suppressed by removing the gasification component contained in a layer insulation film by the process (b). Consequently, coverage can form the contact section which consists of a good aluminum film of low resistance in a contact hole.
[0010] In here, a "gasification component" says gas constituents, such as water generated from a deposit, i.e., a layer insulation film, or a barrier layer, hydrogen, oxygen, or nitrogen, to for example, the bottom of reduced pressure, when substrate temperature is 300 degrees C or more. Moreover, "the bottom of reduced pressure" says more preferably 2.6Pa or less of atmospheric pressure of 1.3Pa or less.
[0011] Moreover, in this invention, 100 degrees C or less of substrate temperature are preferably cooled at ordinary temperature -50 degree C in the aforementioned process (d). By cooling substrate temperature at this process (d), before forming the 1st aluminum film, substrate temperature can fully be lowered. Since substrate temperature is made into the elevated temperature of 300 degrees C or more at the degasifying process of the aforementioned process (b), temperature control in future processes (e) can be certainly performed by reducing substrate temperature certainly at this process (d). Moreover, in case the 1st aluminum film is formed by passing through this process (d), a layer insulation film and a barrier layer, and capacity further emitted from the whole wafer surface can be lessened as much as possible. Consequently, the influence of gas detrimental to the coverage nature and adhesion which stick to the interface of a barrier layer and the 1st aluminum film can be prevented.
[0012] In the aforementioned process (e), by being 30-100 degrees C in temperature preferably, and forming 200 degrees C or less of 1st aluminum film on the aforementioned barrier layer, it can suppress making the gasification component contained in the aforementioned layer insulation film and a barrier layer gasify, and the wettability fall of the barrier layer by the gas which occurs outside from a barrier layer can be prevented. Consequently, the 1st aluminum film can be stuck good to a barrier layer, and good membrane formation of step coverage is possible.
[0013] And though the temperature of a substrate goes up when there is this 1st aluminum film, since generating of the gas from lower layer layer insulation film and barrier layer can be suppressed from the 1st aluminum film, In the membrane formation process (f) of the 2nd aluminum film, 300 degrees C or more of 2nd aluminum film can be preferably formed in the high temperature which is a grade which can carry out flow diffusion of comparatively high temperature, i.e., aluminum, or the aluminium alloy, and a concrete target at 350-450 degrees C.
[0014] Thus, by forming the 2nd aluminum film at comparatively high temperature in the process which forms the 1st aluminum film at low temperature comparatively in a process (e), and a process (f), there is no generating of a void and the embedding to the contact hole of good step coverage becomes possible. Furthermore, it is checked that the manufacture method of this invention is applicable to a 0.2-micrometer contact hole.
[0015] Moreover, it is desirable not to form the so-called wetting layer in the front face of the aforementioned barrier layer. The path of a contact hole is 0.5 micrometers or less, and when an aspect ratio embeds conductive material to the detailed contact hole of 1-4, a wetting layer is formed in order to raise the wettability to the aforementioned conductive material to the front face of a barrier layer, and is usually formed with the film of refractory metals, such as titanium. However, according to the invention-in-this-application person, it is checked that metal

membranes, such as titanium, tend [comparatively] to contain water and hydrogen. Therefore, by not forming a wetting layer in the front face of a barrier layer, the amount of a gasification component can be reduced compared with the case where it has a wetting layer, and generating of the gas leading to [of a void] generating can be suppressed more.
[0016] Membrane formation of the aforementioned process (e) and the aluminum film in (f) has a desirable spatter, and it is [the 1st aluminum film and the 2nd aluminum film] still more desirable to be continuously carried out within the same chamber. Thus, while control of substrate temperature is easy by forming an aluminum film continuously within the same chamber, control of atmosphere etc. can be made exact and it can avoid un-arranging [of an oxide film being formed in the front face of the 1st aluminum film].
[0017] Moreover, as for the aforementioned process (d), (e), and (f), it is desirable to be continuously carried out within the same equipment which has two or more chambers at which the reduced pressure state is maintained. Thereby, movement of a substrate and reduction of the process of installation are achieved, consequently facilitation of a process and contamination of a substrate can be prevented.
[0018] Furthermore, it is desirable to raise barrier property by making oxygen introduce into the aforementioned barrier layer, and forming partially the oxide of the metal which constitutes this barrier layer in a barrier layer after the formation process of the barrier layer of the aforementioned process (c). It can expose into oxygen plasma or the method of heat-treating a substrate in oxygen atmosphere as a method of making oxygen introducing into the aforementioned barrier layer can be adopted.
[0019] The semiconductor device formed by the above manufacture methods The layer insulation film from which it was formed on the semiconductor substrate containing an element, and the aforementioned semiconductor substrate, and the gasification component was removed by heat treatment, The aluminum film which consists of an alloy which makes a principal component the aluminum or aluminum formed on the barrier layer formed in the front face of the contact hole formed in the aforementioned layer insulation film, the aforementioned layer insulation film, and the aforementioned contact hole and the aforementioned barrier layer is included.
[0020] In this semiconductor device, it is characterized by having the layer insulation film from which the gasification component was removed by heat treatment, and as mentioned above, it has the contact section which consists of an aluminum film of good step coverage.
[0021] Moreover, although the contact structure of this invention is applicable suitable for the silicide layer formed in the front face of the impurity diffusion layer which constitutes the source field and drain field of the MOS device, it is not limited to this but can be applied also to the contact in the impurity diffusion layer which does not have other fields or silicide layers.
[0022] Furthermore, although the contact hole in this invention was formed of the dry etching of an anisotropy, it may make the upper-limit section of a contact hole form in others in the shape of a taper moderately combining isotropic wet etching and the dry etching of an anisotropy. For example, it is this type of contact hole, and the aperture of the portion formed of the dry etching of a lower anisotropy is 0.5-0.8 micrometers, and since the 2nd aluminum film can be formed at 300-350 degrees C when aspect ratios are 0.5-3, and the general sputtering system which is not elevated-temperature specification can be used, it is very useful practically.
[0023]
[Embodiments of the Invention] Drawing 1 (A) - (C) is an outline cross section for explaining the manufacture method of the semiconductor device concerning this invention, and the gestalt of 1 operation of a semiconductor device.
[0024] Below, an example of the manufacture method of a semiconductor device is shown.
[0025] (Formation of an element) The MOS device is formed in a silicon substrate 11 by the method generally used first. Specifically, the field insulator layer 12 is formed of selective oxidation on a silicon substrate 11, and the gate oxide film 13 is formed in an active field. The gate electrode 14 is formed by carrying out the spatter of the tungsten silicide on the polysilicon contest film into which the mono silane (SiH_4) was pyrolyzed and was grown up by channel pouring after adjusting threshold voltage, carrying out the laminating of the silicon oxide 18

further, and ***********ing to a predetermined pattern. At this time, the wiring layer 37 which consists of a polysilicon contest film and a tungsten silicide film is formed on the field insulator layer 12 if needed.
[0026] Subsequently, the low concentration impurity layer 15 of a source field or a drain field is formed by carrying out the ion implantation of Lynn. Subsequently, after the side-attachment-wall spacer 17 which becomes the side of the gate electrode 14 from a silicon oxide is formed, the high concentration impurity layer 16 of a source field or a drain field is formed by carrying out the ion implantation of the arsenic and activating an impurity by annealing processing using the halogen lamp.
[0027] Next, a predetermined silicon-substrate field is exposed by carrying out the vapor growth of the silicon oxide 100nm or less, and ***********ing alternatively with the mixed-water solution of HF and NH4F. then — for example, the silicon-substrate front face which carried out opening by carrying out the spatter of the titanium by about 30-100nm thickness, and performing moment annealing for several seconds - about 60 seconds at the temperature of 650-750 degrees C into the nitrogen-gas-atmosphere mind which controlled oxygen to 50 ppm or less — the monochrome silicide layer of titanium — a silicon-oxide 18 top — titanium — a rich CHITSU-ized titanium (TiN) layer is formed Subsequently, if immersed into NH4OH and the mixed-water solution of H2O2, it will *********** and, as for the aforementioned TiN layer, the monochrome silicide layer of titanium will remain only in a silicon-substrate front face. Furthermore, perform 750-850-degree C lamp annealing, the aforementioned monochrome silicide layer is made to form into die silicide, and the titanium silicide layer 19 is formed in the front face of the high concentration impurity layer 16 at a self-adjustment target.
[0028] In addition, when the gate electrode 14 is formed only with contest polysilicon and it is made to expose by selective etching, both a gate electrode, source, and drain field become the CHITANSA LISA id structure separated with the side-attachment-wall spacer.
[0029] (Formation of a layer insulation film) Next, the silicon oxide 20 of 100-200nm of thickness is first formed as some layer insulation films by carrying out the plasma reaction of a tetrapod ethoxy run (TEOS) and the oxygen. This silicon oxide 20 does not have oxidization or the dregs ping of the titanium silicide layer 19, either, and highly [insulation], its etch rate to the solution of hydrogen fluoride is also slow, and it turns into a precise film from the film grown up from SiH4.
[0030] Since a oxidizing gas and titanium silicide will tend to produce a crack and exfoliation simply in response to the early stages of membrane formation here if the membrane formation temperature at this time is high although a direct silicon oxide is made to form on the titanium silicide layer 19, as for processing temperature, it is preferably desirable to carry out at 250-400 degrees C more preferably 600 degrees C or less. And if it is annealing and vapor-phase-oxidation processing which are exposed to oxidizing atmospheres other than a steam after [which the silicon oxide mentioned above in about 100nm thickness on the titanium silicide layer 19] being comparatively formed at low temperature, it will not become a problem even if it raises temperature to 900-degree-C grade.
[0031] Next, the BPSG film 30 of the number 100nm - 1-micrometer grade of thickness is formed on the aforementioned silicon oxide 20 as some layer insulation films by carrying out gaseous phase reaction of the gas containing silane compounds, such as SiH4 or TEOS, and Lynn and boron. [oxygen, ozone, etc. and] Then, 800-900-degree C annealing is performed in nitrogen-gas-atmosphere mind, and flattening by the elevated-temperature flow is performed. In addition, instead of performing the elevated-temperature flow of the BPSG film 30, chemical mechanical polish (CMP) or the SOG film generally used can be used, and flattening can also be performed.
[0032] (Formation of a contact hole) The contact hole 32 whose aperture is 0.2-0.5 micrometers is formed by carrying out anisotropic etching of the BPSG film 30 and silicon oxide 20 which subsequently constitute a layer insulation film from a reactant ion etcher which made CHF3 and CF4 the main gas alternatively.
[0033] (Degasifying processing) next, ****** including the degasifying process by which this invention is characterized — it ****** just

[0034] First, lamp heating for 30 – 60 seconds (heat treatment A) is given by the lamp chamber at the base pressure of 1x10 – 4 or less Pa, and the temperature of 150–250 degrees C. Subsequently, degasifying processing is performed by introducing argon gas by the pressure of 0.1–1.0Pa by another chamber, and performing heat treatment for 30 – 120 seconds (degasifying process; heat treatment B) at the temperature of 300–550 degrees C.
[0035] In this process, the moisture adhering to the wafer etc. is removable by mainly heat-treating the whole wafer including the rear face and the side of a wafer in heat treatment A first.

[0036] Furthermore, in heat treatment B, the gasification component in the BPSG film 30 which constitutes a layer insulation film (oxygen, hydrogen, water, nitrogen) is mainly removable. Consequently, generating of the gasification component from a BPSG film can be prevented at the time of formation of the barrier layer of the following process, and an aluminum film.
[0037] The barrier layer 33 is constituted in the gestalt of this operation by the multilayer which consists of a barrier film which has barrier ability, and an electric conduction film. An electric conduction film is formed between a barrier film and an impurity diffusion layer, in order to raise conductivity with the impurity diffusion layer formed in the barrier film and silicon substrate of high resistance, i.e., a source field, and a drain field. As a barrier film, night RAIDO, such as common matter, for example, titanium, and cobalt, can be used preferably. Moreover, refractory metals, such as titanium and cobalt, can be used as an electric conduction film. These titanium and cobalt react with the silicon which constitutes a substrate, and serve as silicide.
[0038] Since it dissolves the gasification component (oxygen, hydrogen, water, nitrogen) of dozens atom %, before a barrier layer, for example, a TiN film / Ti film, forms these films, it is very effective [film] to remove the gasification component in the BPSG film 30 of a layer insulation film, when forming the aluminum film within a contact hole good. If the gasification component in the BPSG film of the low rank of a barrier layer is not fully removed, at the temperature at the time of formation of a barrier layer (usually 300 degrees C or more), the gasification component in a BPSG film will be emitted and this gas will be incorporated in a barrier layer. Furthermore, in order that this gas may secede from a barrier layer at the time of membrane formation of an aluminum film and may come out to the interface of a barrier layer and an aluminum film, it has a bad influence on the adhesion of an aluminum film, or a fluidity.
[0039] (Membrane formation of a barrier layer) By the spatter, as an electric conduction film which constitutes the barrier layer 33, a titanium film is formed by 20–70nm thickness, and, subsequently a TiN film is formed as a barrier film by another chamber at 30–150nm thickness. The temperature which forms a barrier layer is chosen in 200–450 degrees C according to thickness.
[0040] Next, titanium oxide can be formed in the shape of an island into a barrier layer by exposing for 10 – 100 seconds into oxygen plasma by the pressure of 10–100Pa, and carrying out annealing processing over 10 – 60 minutes in 450–700–degree C nitrogen or hydrogen atmosphere. It is checking that the barrier property of a barrier layer can be raised by this processing.
[0041] Moreover, 400–800–degree C heat treatment in the lamp annealing furnace which contains hundreds of ppm – several% of oxygen at least can also perform this annealing processing, and the barrier property of a barrier layer can be raised similarly.
[0042] (Heat treatment before membrane formation of an aluminum film) First, before cooling a wafer, heat treatment for 30 – 60 seconds (heat treatment C) is performed in a lamp chamber at the base pressure of 1x10 – 4 or less Pa, and the temperature of 150–250 degrees C, and matter, such as water adhering to the substrate, is removed.
[0043] (Cooling of a wafer) Before forming an aluminum film, 100 degrees C or less of substrate temperature are preferably lowered to ordinary temperature –50 degree C temperature. This cooling process is important in order to lower the substrate temperature which rose with the above-mentioned heat treatment C.
[0044] Thus, in case the 1st aluminum film is formed by cooling a wafer, the BPSG film 30 and the barrier layer 33, and capacity further emitted from the whole wafer surface can be lessened as much as possible. Consequently, the influence of gas detrimental to the coverage nature and

adhesion which stick to the interface of the barrier layer 33 and the 1st aluminum film 34 can be prevented.
[0045] As for this cooling process, it is desirable to be carried out by making the sputtering system which has two or more chambers for forming an aluminum film and chambers of the same composition serve a double purpose. For example, it is desirable to lay a substrate on the stage which has the water-cooled function prepared in the chamber, and to lower this substrate temperature to predetermined temperature. Below, this cooling process is explained in full detail.
[0046] In drawing 2 (a), drawing 2 (b) shows the plan of an example of a stage for the ** type view of an example of a chamber including the stage which has a water-cooled function.
[0047] A sputtering system is equipped with two or more chambers 50 of the same composition. It has the electrode 52 which serves both as the target 51 which serves as an electrode in a chamber 50, and a stage, and it is constituted so that the substrate (wafer) W cooled may be installed on an electrode 52. The 1st gas supply way 53 for supplying the exhaust air means 60 and gas for making the inside of a chamber into a vacuum in a chamber is established in the chamber 50. Along with the periphery portion of the upper surface of an electrode 52, support r 52a of the letter of a salient is specifically prepared like drawing 2 (b) so that predetermined space may produce it between an electrode 52 and Substrate W, when an electrode 52 lays Substrate W on an electrode 52. Furthermore, the 2nd gas supply way 54 is connected to the electrode 52. And it is supplied to the space between an electrode 52 and Substrate W from the 2nd gas supply way 54, the gas, for example, the argon gas, as a heat-conduction medium. Moreover, the electrode 52 is also holding an additional post of the role of the cooling system for cooling Substrate W. An electrode 52 is adjusted by constant temperature by reflux of the refrigerant supplied from the refrigerant supply way 56, for example, water. In order for the upper surface of an electrode 52 to make gas supply to the aforementioned space uniformly as shown in drawing 2 (b), a slot 58 is formed by the predetermined pattern and diffuser 54a of the 2nd gas supply way 54 is prepared in the portion which a slot intersects.
[0048] The above-mentioned chamber operates as follows and cools a wafer.
[0049] Substrate W is laid for the inside of a chamber 50 on supporter 52a of an electrode 52 by the exhaust air means 60 as a reduced pressure state of 6x10 - 6 or less Pa. Substrate W is cooled exhausting the gas which introduced into the space between an electrode 52 and Substrate W the gas which plays a role of a heat-conduction medium between an electrode 52 and Substrate W from the 2nd gas supply way 54, and kept the pressure of this space at 600-1000Pa, and was leaked in the chamber from this space with the exhaust air means 60.
[0050] In case Substrate W is cooled, in order to maintain cooling efficiency, a certain amount of pressure is required for the space between an electrode 52 and Substrate W. That is, in order to raise the cooling efficiency of Substrate W, it is necessary to raise the thermal conductance between an electrode 52 and Substrate W, and in order to be this improvement, it is necessary to heighten the pressure of the gas (heat-conduction medium) of the space between an electrode 52 and Substrate W.
[0051] How to cool in a vacuum chamber as the cooling method of a substrate by laying a substrate on the stage which has a cooler style in a chamber can be considered. In order according to this cooling process to make it depend for the pressure of this space on the pressure in a chamber rather than to supply gas to the space between a stage and a substrate directly and to heighten the pressure of the space between a stage and a substrate, it is necessary to heighten the pressure in a chamber. However, since the gas molecule in a chamber will increase so much if the pressure in a chamber is heightened in order to raise cooling efficiency, the situation where the upper surface of Substrate W becomes is easy to be polluted in a gas molecule may arise, the reflow of aluminum may be injured by that cause, and it may lead to generating of a void, and high resistance-ization of wiring. Conversely, if the pressure in a chamber is made low in order to prevent contamination of a wafer, the pressure of the space between a wafer and a stage will also decline, and the thermal conductance between a wafer and a stage will fall by this, consequently cooling efficiency will become bad.
[0052] Since according to the cooling process of the above-mentioned gestalt of this operation gas is made to flow between an electrode 52 and the rear face of Substrate W and this secures

the pressure of the space between an electrode 52 and Substrate W, the pressure of this space is controllable independently of the pressure in a chamber. And th pressure in a chamber can be stopped independently from a viewpoint of reservation of the heat-conduction medium between a substrate and a stage to the pressure of 1x10-3-0.1Pa with the pressure of the aforementioned space. Thereby, contamination of the upper surface of the substrate by the gas molecule can be prevented c rtainly, consequently the improvement in reflow nature and the reduction in resistance of aluminum are brought about. Furthermore, since the pressure of the aforementioned space can be set as the range of 600-1300Pa, without heightening the pressure in a chamber, a thermal conductance can improve and cooling efficiency can be raised. Thus, according to this cooling process, good cooling efficiency can be acquired, preventing contamination of a substrate, since the pressure in a chamber can be lowered heightening the pressure of the space between Substrate W and an electrode 52.
[0053] (Membrane formation of an aluminum film) First, it is 30-100 degrees C in temperature more preferably, and the aluminum containing 0.2 - 1.0% of the weight of copper is formed at high speed by the spatter by 150-300nm of thickness, and 200 degrees C or less of 1st aluminum film 34 are formed. Then, it heats in substrate temperature of 350-460 degrees C within the same chamber, the aluminum which contains copper similarly is formed by the low speed by the spatter, and the 2nd aluminum film 35 of 300-600nm of thickness is formed. Here, in membrane formation of an aluminum film, although neither membrane formation conditions nor the design matter of a device manufactured can prescribe "high speed" generally, a sputtering rate 10nm [/second] or more is meant about, and a "low speed" means a sputtering rate 3nm [/second] or less about.
[0054] The spatter of aluminum is performed by another chamber in the sputtering system used on the occasion of cooling of the above-mentioned wafer. This chamber has the same composition as the chamber shown in drawing 2 (a) and (b). Thus, by performing a cooling process and the process of membrane formation of aluminum within the same equipment with which the reduced pressure state was maintained, movement of a substrate and reduction of the process of installation are achieved, consequently facilitation of a process and contamination of a substrate can be prevented.
[0055] Here, argon gas is supplied from [each] the 1st gas supply way 53 and the 2nd gas supply way 54. And the temperature of Wafer W is controlled by the gas supplied from the 2nd gas supply way 54.
[0056] An example which controlled substrate temperature using such a sputtering system is shown in drawing 3 . In drawing 3 , a horizontal axis shows elapsed time and a vertical axis shows substrate (wafer) temperature. Moreover, in drawing 3 , the line which the line shown with Sign a shows the substrate temperature change when setting the temperature of the stage 52 of a sputtering system as 350 degrees C, and is shown with Sign b shows change of the substrate temperature when raising the temperature of a stage 52 by supplying argon gas in a chamber through the 2nd gas supply way 54.
[0057] For example, the temperature control of a substrate is performed as follows. First, the temperature of a stage 52 is beforehand set as the temperature (350-500 degrees C) for forming the 2nd aluminum film. In case the 1st aluminum film is formed, there is no supply of the gas from the 2nd gas supply way 54, and substrate temperature rises gradually by heating by the stage 52, as the sign a of drawing 3 shows. By supplying the gas heated through the 2nd gas supply way 54, in case the 2nd aluminum film is formed, substrate temperature rises rapidly and is controlled to become fixed at predetermined temperature so that the sign b of drawing 3 shows.
[0058] In the example shown in drawing 3 , stage temperature is set as 350 degrees C, while substrate temperature is set as 125-150 degrees C, the 1st aluminum film 34 is formed, and membrane formation of the 2nd aluminum film 35 is performed immediately after that.
[0059] In membrane formation of an aluminum film, control of the power impressed to a sputtering system with membrane formation speed and a substrate temperature control is also important. That is, although membrane formation speed is related, in case membrane formation of the 1st aluminum film 34 is performed by high power, the 2nd aluminum film 35 is performed

by low power and it switches to low power from still higher power, it is important not to make power into zero. If power is made into zero, an oxide film will be formed in the bottom of reduced pressure on the front face of the 1st aluminum film, the wettability of the 2nd [to the 1st aluminum film] aluminum film will fall, and both adhesion will become bad. In other words, by always impressing power, supplying activity aluminum to the front face of the aluminum film under membrane formation can be continued, and formation of an oxide film can be suppressed. In addition, although the size of power cannot generally be specified depending on a sputtering system, membrane formation conditions, etc., in the case of the temperature conditions shown, for example in drawing 3 , it is desirable [a size] to set 5-10kW and low power as 300W-1kW for high power.

[0060] Thus, by forming continuously the 1st aluminum film 34 and the 2nd aluminum film 35 within the same chamber, control of temperature and power can be performed strictly and it becomes possible to form efficiently the aluminum film which is low temperature and was stabilized rather than before.

[0061] The proper range is chosen in consideration of the ability to suppress discharge of the gasification component from the BPSG film 30 which constitutes lower layer barrier layer 33 and layer insulation film from that a continuation layer can be formed and this aluminum film 34 by good step coverage, for example, the thickness of the aluminum film 34 of the above 1st has desirable 200-400nm. Moreover, in order to be determined by the size of a contact hole, its aspect ratio, etc., for example, for an aspect ratio to fill a hole 0.5 micrometers or less about by three, 300-1000nm thickness is required for the 2nd aluminum film 35.

[0062] (Membrane formation of an antireflection film) The antireflection film 36 of 30-80nm of thickness is formed by depositing TiN by the spatter by still more nearly another spatter chamber. Then, the deposit which consists of the aforementioned barrier layer 33, the 1st aluminum film 34, the 2nd aluminum film 35, and an antireflection film 36 by the anisotropy dry etcher which makes the gas of Cl2 and BCl3 a subject is ***********ed alternatively, and patterning of the metal wiring layer 40 is performed.

[0063] Thus, in the formed metal wiring layer 40, it was checked that aluminum is embedded by good step coverage, without an aspect ratio generating a void in 0.5-3 in the contact hole whose aperture is 0.2-0.8 micrometers.

[0064] (Example of an experiment)

(1) The experimental result performed in order to investigate a difference of the amount (partial pressure) of the gas emitted to drawing 4 and drawing 5 by the existence of a degasifying process from a wafer is shown.

[0065] In drawing 4 and drawing 5 , the timing of processing is shown until a horizontal axis results after membrane formation of the 2nd aluminum film 35 from heat treatment (heat treatment C) performed before formation of an aluminum film, and the vertical axis shows the partial pressure of the residual gas in a chamber. In drawing 4 and 5, when the line shown with Sign A passes through a degasifying process after formation of a layer insulation film, the line shown with Sign B shows the case where it does not pass through a degasifying process after formation of a layer insulation film. The degasifying process was performed by this example of an experiment in atmospheric pressure [of 0.27Pa], temperature [of 460 degrees C], and time 120 seconds.

[0066] In each drawing, the signs a and b of a horizontal axis show the timing in the heat treatment C (the 1st chamber) performed before membrane formation of an aluminum film, and Sign a shows the time of Sign b heating a wafer for 60 seconds at 250 degrees C by lamp heating at the time immediately after putting in a wafer in the 1st chamber. In the 1st chamber, atmospheric pressure is set as 2.7x10 to 6 Pa.

[0067] Signs c and d show the timing in the cooling process (the 2nd chamber) of a wafer, and Sign c shows the time of Sign d cooling the temperature of a wafer to 20 degrees C at the time immediately after putting in a wafer in the 2nd chamber. In the 2nd chamber, atmospheric pressure is set as 0.27Pa. And when measuring a partial pressure, the atmospheric pressure of a chamber was decompressed up to 2.7x10 to 6 Pa.

[0068] Signs e, f, and g show the timing in the membrane formation process (the 3rd chamber) of

an aluminum film, and the time immediately after Sign f forms the 1st aluminum film, and immediately after Sign g forms the 2nd aluminum film is shown at the time immediately after Sign e puts in a wafer in the 3rd chamber. In the 3rd chamber, atmospheric pressure is set as 0.27Pa. And when measuring a partial pressure, the atmospheric pressure of a chamber was decompressed up to 2.7x10 to 6 Pa.

[0069] From drawing 4 and drawing 5 , it is after membrane formation of a layer insulation film, and it was checked by performing a degasifying process before membrane formation of a barrier layer that water and nitrogen do not carry out ******** generating at the time of subsequent heat treatment and membrane formation of an aluminum film. On the other hand, in not passing through the aforementioned degasifying process, it turns out that both water and nitrogen are emitted so much at the time of subsequent heat treatment, especially the heat treatment C shown with Sign b.

[0070] (2) The following knowledge was acquired when it experimented in order for the existence of the cooling process of the wafer before membrane formation of an aluminum film to investigate what influence is brought to membrane formation of aluminum. In addition, membrane formation of aluminum was performed in the conditions of the aspect ratio 3.18 of a contact hole, and 1148nm of thickness of a layer insulation film. Drawing 8 (a) shows drawing for which it asked from the electron microscope photograph of the cross section of the wafer at the time of forming aluminum after cooling a wafer from the temperature of 120 degrees C of heat treatment C to 20 degrees C, and drawing 8 (b) shows drawing for which it asked from the electron microscope photograph of the cross section of the wafer at the time of forming aluminum at the temperature of 120 degrees C of heat treatment C, without cooling a wafer.

[0071] [when comparison examination of the substrate after membrane formation of the aluminum at the time of cooling a wafer and it when not cooling was carried out and it cools] [as shown in drawing 8 (a), when not cooling to the 1st and 2nd aluminum films (A1) having been embedded very good at the contact hole] As shown in drawing 8 (b), an aluminum film was not completely embedded at the pars basilaris ossis occipitalis of a contact hole, but the contact hole which space (void) 100 produces occurred about 30 percent of the number of contact holes on a wafer.

[0072] (3) Drawing 6 and drawing 7 show the measurement result by the secondary ion mass spectrometry (SIMS) by irradiation of primary caesium ion.

[0073] Drawing 6 shows the data of the layered product which has a membrane structure (a TiN film / aluminum film / TiN film / Ti film) when not having a wetting layer between a barrier layer and the 1st aluminum film, and drawing 7 is data of the layered product which has a membrane structure in the case of having the wetting layer which consists of titanium between a barrier layer and the 1st aluminum film (a TiN film / aluminum film / Ti film / TiN film / Ti film). In drawing 6 and 7, a left-hand side vertical axis shows quantitatively the hydrogen in aluminum film, nitrogen, and oxygen, and the right-hand side vertical axis shows the secondary ionic strength of layers other than aluminum film.

[0074] In addition, the sample of the experiment shown in drawing 6 is formed by the method which the degasifying process of the above (C) was not performed, and also was mentioned above. Moreover, the sample of the experiment shown in drawing 7 differs from the sample of the experiment shown in drawing 6 in that it has Ti film under aluminum film.

[0075] From drawing 6 and 7, in aluminum film, hydrogen, oxygen, and nitrogen are background level, and are below the marginal detection concentration in SIMS, and hardly dissolving was checked.

[0076] Moreover, when there is a wetting layer (Ti film), as shown in drawing 7 , it turns out that the big peak of the hydrogen (H) shown with Sign PH is in this film, and a lot of hydrogen is therefore contained in a wetting layer.

[0077] If H in this wetting layer or OH is excited by the radiant heat of plasma etc. and it is emitted as water or hydrogen gas at the time of membrane formation of a subsequent aluminum film when there is a wetting layer, since these gas does not dissolve in an aluminum film, it will accumulate in both interface, and this will become the fall of adhesion, and the cause of a void from the above thing.

[0078] Thus, although it was formed in order that a wetting layer (Ti film) might generally raise the wettability to an aluminum film, the cause and bird clapper which generate the problem mentioned above at the subsequent heating process w re solved. Especially the wafer after contact hole formation has the place which has absorbed moisture partially, and it was checked that it is easy to generate the poor contact and poor electromigration by the void in a moisture absorption portion by existence of a wetting layer.
[0079] Moreover, if compounds, such as aluminum3Ti, are partially formed for the titanium which constitutes a wetting layer in response to the time of formation of the 1st aluminum film with aluminum and this exists at the time of membrane formation of the 2nd ARUMINIMU film, when there is a wetting layer, in order to reduce the surface flow nature of aluminum, **** of aluminum becomes imperfect and a void becomes is easy to be formed. It is easy to be generated at the entrance of a contact hole, and the so-called pinch-off becomes easy to generate especially this phenomenon. And this pinch-off is embedded smell ****** and the cone of a contact hole which have a diameter 0.3 micrometers or less.
[0080] Furthermore, when there is a wetting layer, the titanium which constitutes this wetting layer returns the titanium oxide which exists in a barrier layer, and the barrier property of a barrier layer may be reduced.
[0081] It is desirable not to form a wetting layer by the wiring layer of the 1st layer at least of such a reason. And since the process for it is not needed unless a wetting layer is formed, a manufacturing process can be shortened.
[0082] In this invention, as mentioned above, even if it does not form a wetting layer by performing degasifying processing of a layer insulation film after formation of a contact hole, and having the process which fully cools a wafer before membrane formation of an aluminum film further, it has adhesion with sufficient barrier layer and 1st aluminum film. And since gas, such as hydrogen contained in a lower layer, nitrogen, and oxygen, is fully removed from the 1st aluminum film by degasifying processing and these gas moreover cannot pass the 1st aluminum film, the front face of the 1st aluminum film is very pure. Therefore, at the time of formation of the 2nd aluminum film, aluminum flows the front face of the 1st aluminum film smoothly, and a good buried layer is formed.
[0083] In this invention, the following things can be considered as a reason the 1st and 2nd aluminum films 34 and 35 were embedded good at the contact hole.
[0084] (a) Raised the adhesion of the barrier layer 33 and the 1st aluminum film 34 by preventing generating of the gas from the BPSG film 30 or the barrier layer 33 in the 1st subsequent aluminum film 34 and membrane formation of the 2nd aluminum 35 by gasifying water and nitrogen which are contained in a layer insulation film, especially a BPSG film by performing a degasifying process, and fully emitting, and membrane formation of good step coverage was possible for.
[0085] (b) what the adhesion of the 1st aluminum film 34 was raised for in addition to the effect of the aforementioned degasifying process as the moisture or nitrogen which are contained in the BPSG film 30 and the barrier layer 33 in substrate temperature 200 degrees C or less by setting it as low temperature comparatively were not made to emit in membrane formation of the 1st aluminum film 34
[0086] (c) Since the 1st aluminum film 34 the very thing plays further the role which suppresses generating of the gas from a lower layer when substrate temperature goes up, the 2nd following aluminum film 35 can be formed at comparatively high temperature, and flow diffusion of the 2nd aluminum film can be performed good.
[0087] As mentioned above, according to this invention, by forming an aluminum film continuously within the same chamber further including a degasifying process and a cooling process at least before the spatter of an aluminum film, it became possible to embed the contact hole to about 0.2 micrometers only by aluminum or the aluminium alloy, and improvement was able to be aimed at in respect of reliability and the yield. Moreover, there are also no copper segregation and unusual growth of crystal grain in the aluminum film which constitutes the contact section, and the good thing was checked also in respect of reliability including migration etc.

[0088] In addition, although the gestalt of the above-mentioned implementation explained the semiconductor device containing the N channel type MOS device, it is applicable also to the semiconductor device containing a P channel type or a CMOS type element.
[0089] Moreover, with the gestalt of the above-mentioned implementation, although **** of the aluminum film in the contact hole of the 1st layer was explained, embedded ******** of the aluminum film in the wiring layer of the 2nd more than (the 2nd lay r, the 3rd layer, and the 4th layer) layer is also checking the same effect.
[0090]

[Translation done.]

* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] (A), (B), and (C) are the cross sections showing typically an example of the manufacture method of the semiconductor device of this invention in order of a process.
[Drawing 2] Drawing 2 (a) is drawing showing typically an example of the sputtering system used for the gestalt of operation concerning this invention, and drawing 2 (b) shows the plan showing an example of a stage.
[Drawing 3] It is drawing showing the relation of the time and substrate temperature when controlling substrate temperature using the sputtering system shown in drawing 2 .
[Drawing 4] It is drawing in the manufacture method of the semiconductor device concerning this invention showing the relation of the partial pressure of the residual gas in processing timing and a chamber(water).
[Drawing 5] It is drawing in the manufacture method of the semiconductor device concerning this invention showing the relation of the partial pressure of the residual gas in processing timing and a chamber (nitrogen).
[Drawing 6] It is drawing showing the data of SIMS in the layer structure which does not have a wetting layer.
[Drawing 7] It is drawing showing the data of SIMS in the layer structure which has a wetting layer.
[Drawing 8] Drawing 8 (a) shows drawing based on the electron microscope photograph of the cross section of the wafer at the time of forming aluminum, after cooling a wafer, and drawing 8 (b) shows drawing based on the electron microscope photograph of the cross section of the wafer at the time of forming aluminum, without cooling a wafer.
[Description of Notations]
11 Silicon Substrate
12 Field Insulator Layer
13 Gate Oxide Film
14 Gate Electrode
15 Low Concentration Impurity Layer
16 High Concentration Impurity Layer
17 Side-Attachment-Wall Spacer
18 20 Silicon oxide
19 Titanium Silicide Layer
30 BPSG Film
32 Contact Hole
33 Barrier Layer
34 1st Aluminum Film
35 2nd Aluminum Film

[Translation done.]